A CASE STUDY OF THE PRODUCTION STRATEGIES OF FOUR WELLS FOR OPTIMIZINGN THE GAS RECOVERY FROM WATER DRIVE DRY GAS RESERVOIR

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ABSTRACT

Nowadays, many gas recovery techniques have been practiced in order to meet the current demand of market. Simultaneously producing gas and water from their respected zones is a viable production technique and provides additional benefits and maximizes the recovery as compared to conventional technique.

In this study, the important production strategies i.e (i) Conventional, (ii) Blowdown & (iii) Co-production are considered for evaluation and sensitivity analysis for a water drive dry-gas reservoir by using a field data simulation. The gas recovery target can be achieved by selecting the optimum production strategy resulting in the maximized reserves and improved recovery factor.

INTRODUCTION

The water drive dry gas reservoir (WDDGR) is one of the most economical drive methods. Many production techniques are to being used for enhancement of the recovery of gas from such type of drives. Among them, the co-production is a viable production technique and commonly used nowadays for optimizing the gas recovery from water drive dry gas reservoir. By the co-production technique, the 21% Ultimate gas recovery (UGR) has been improved in a Gulf-coast Eugene Island Reservoir [1]. Another study showed that predicted recovery of the field yielded 83% of Ultimate recovery factor (URF) as compared to 62% for conventional production [2].

LITERATURE REVIEW

Following is a brief overview of relevant literature.

Cohan (1989) inquired a bottom / edge water drive dry gas reservoir and found that the 'conventional wisdom' with regard to the production strategy may sometime needs to be modified according to conditions in the reservoir. He established that it is not necessary that accelerated production always yields more ultimate recovery [3].

McMullan et. al. (2000) investigated the effect of accelerated gas withdrawal rates and concluded that the elevated gas never harmfully impacts the UGR. In the lower permeability systems, accelerated gas withdrawal rates yielded significantly improved UGR [4].

Sech et. al. (2007) investigated the risks associated with the accelerated production in horizontal wells and suggested that in a bottom-water drive higher production rates via large-bore horizontal wells do not result in an enhanced URF. Despite this, there are many cases where accelerated production shows a little less URF but may be more economically favorable [5].

Stein et. al. (2009) presented various case studies and discussed various operating conditions. Conclusion of this study was that by using an Integrated Asset Modeling approach, gas field performance can be optimized and thereby it can result in increasing the reserves by enhancing gas production rates [6].

Rezaee et. al. (2013) determined that there is an optimum flow rates area, in a graph between gas flow rate and recovery factor (RF), which could yield the maximum recovery factors. This determination of optimization could be done on laboratory scale on reservoir sample rock for development of WDDGR [7].

Naderi et. al. (2014) worked on optimizing production from WDDGR based on desirability concept and concluded that accelerating gas production decreases URF by 3.2% to 8.4% because of poor Volumetric sweep efficiency and early water breakthrough, but it may be economically feasible if timescales are short. Further, increasing production rate from 60 to 120 MMSCF/D increases Gas RF by 8% [9].

Thomas (2005) suggested that ideally coproduction should begin simultaneously with gas production, which may need intentional drilling of water well in aquifer. Mostly it is preferred to turnaround the gas well into water wells once water has shut gas well's production [9].

CASE STUDY

In Sindh Province of Pakistan, the M-reservoir was found in Southern Mid Indus Platform Basin (known as Zone-III) as shown in Fig.1. The evaluation and a sensitivity analysis were done in this reservoir and various parameters were logged. After that, the best parameters for production strategy would be opted.

The following production strategies are used for evaluation and a sensitivity analysis for optimizing the gas recovery from WDDGR:

1. Conventional Production, 2. Blowdown, 3. Co-Production

Figure 1: Southern Mid Indus Platform Basin Zone-III (M-RESERVOIR).

RESERVOIR AND WELL DESCRIBTION

Reservoir has a keystone shape, three way dip and with is supported with the edge water drive. Four wells (W-1, W-2, W-3 & W-4) having 4.5 inch OD are located in A, B & C locations. W-1, W-2, W-3 are in gas zone while W-4 is in water zone.

EXPERIMENT CASES

Following three cases, as discussed in the literature review section, are constructed.

1. Conventional (Restricted) Low Rate Production Strategy / Technique
2. Blow-down (Out-running) Accelerated Production Strategy / Technique
3. Co-Production Strategy / Technique

The construction of experimental cases is discussed below: -

1. Conventional Restricted Technique

The construction of the Conventional (restricted) technique case with assumptions is discussed herewith.

i) **Flowrates:** Low rate production rate is taken - maximum of 20 MMSCF/D per well.
ii) **Wells:** Production is taken from three wells in the gas zone only.
iii) **Production Strategy:** Production time will continue until all gas wells are shut due to high water cut.
iv) Depletion of pressure will be slower, due to low rate of production and more production time.
v) There is a facility in place for gas processing.

2. Blow-down Technique

The construction of the Blow-down technique case with assumptions is discussed herewith.

i) **Flowrates**: Accelerated production rates are relied upon in this. Production rate of twice the conventional restricted approach are considered. A maximum gas production rate of 40 MMSCF/D per well is carried out.
ii) **Wells**: Production is taken from three wells, which are produced from the gas zone only.
iii) **Production Strategy**: Production time will continue until all gas wells are shut due to high water cut.
iv) Depletion of pressure will be faster, due to accelerated production rate and less production time.
v) There is no processing facility constraint.
vi) Market requirement is there and agreements are in-place.

3. Co-Production Technique

The construction of the Co-Production technique case with assumptions is discussed herewith.

i) **Flowrates**: Accelerated production rates are relied upon in this. Production rate of twice the conventional restricted approach and the same as in the blowdown approach is xonsidered. A maximum gas production rate of 40 MMSCF/D per well is carried out. This is done to compare this with the Blowdown approach. There is a water-well in the aquifer zone that produces at 25,000 STB/d.

ii) **Wells**: Gas Production is taken from 3 (three) wells, which are produced from the gas zone only. Simultaneously water production is carried out in order to deplete the reservoir pressure and retard the aquifer advance.

iii) **Production Strategy**: Production time will continue until all gas wells are shut due to lower limit of tubing head pressure which is set at 500 psi.

iv) Depletion of pressure will be faster, due to accelerated production rate and moderate production time.

v) There is no processing facility constraint.

vi) There is a water disposal well available.

vii) Market requirement is there and agreements are in-place.

All above cases are summarized in table 1:

Table 1: The development of cases.

Well	Pre-dominant Producing fluid	Maximum withdrawal rates along with status					
		Conventional Technique		**Blowdown Technique**		**Coproduction Technique**	
		Gas Production in MMSCF/D	status	Gas Production in MMSCF/D	Well status	Gas Production in MMSCF/D	Well status
W-1							
W-2	Gas	20.00	Open	40.00	Open	40.00	
W-3							Open
W-4	Water	00 MSTBD	Shut	00 MSTBD	Shut	25.00 MSTBd	

RESULT AND DISCUSSION

The following results have been concluded from this simulation study:

1. The gas production rate of all four wells (i.e W-1, W-2, W-3 & W-4) changed with respect to the production strategies.
2. The simulation results are illustrated from Fig.2 to 4. These results show the pressure behavior, gas saturation and water saturation at initial and final condition in all prescribed production strategies and will help in understanding the behavior of gas flow.
3. Gas Production rate of W-1, W-2, W-3 from well analysis are;
    (a) At constant rate of 20 MMSCF/D for a longer time from Conventional.
    (b) At constant rate of 40 MMSCF/D for shorter time from blowdown and co-production.
    (c) As certain time is passed, the pressure drop will be faster as the change of rate is greater due to depletion/production rate. The production summary of co-production deviates in three producing gas wells from that of blowdown. This may be logic when response of aquifer is observed and the water breakthrough in gas wells, which is produced with rapid change as the wells are shut in blowdown technique.
    (d) But, in the case of co-production technique the wells maintain to produce at the same time due to drainage of huge amounts of water from the edge using W-4. No production

of gas is seen from W-4 throughout the whole life of the well as this well has been drilled in the water zone.

CONCLUSIONS

1. The satisfactory selection of production strategy plays a crucial role in the optimization of gas recovery and reserves.

2. The drilling of additional well of water for water production on the edge (keystone shape) may result in an optimized gas production.

3. The co-production strategy provides better results as compared to blowdown and conventional techniques in terms of produced maximum gas rate, incremental reserves and the techno-economic factors.

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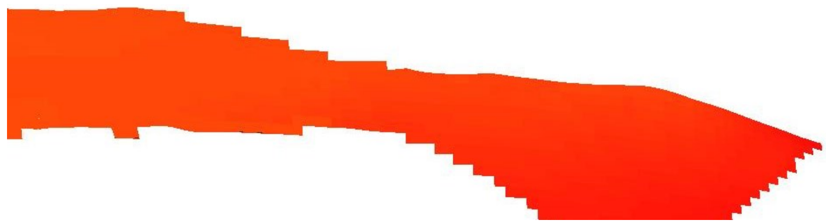
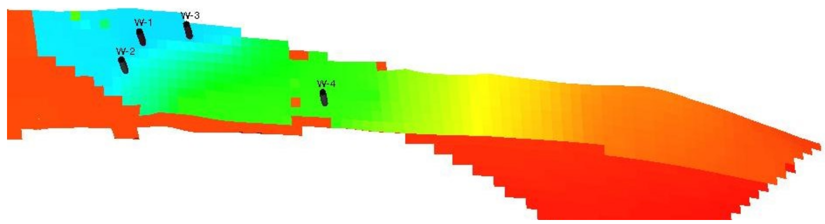
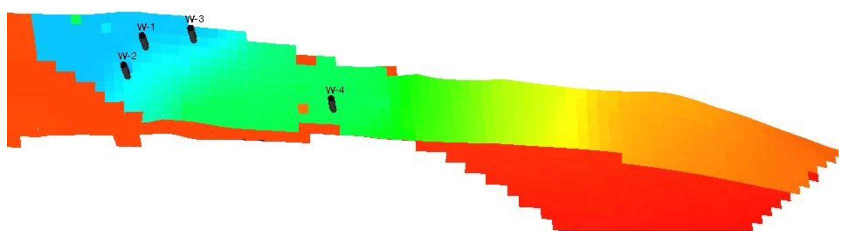


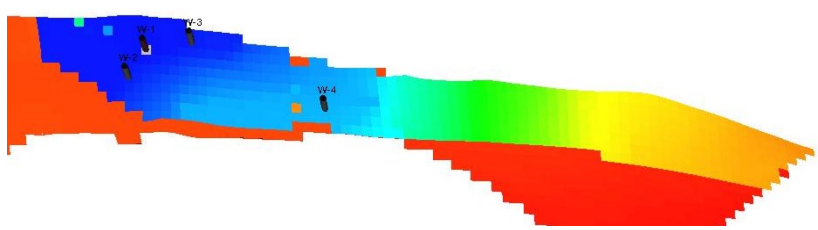
(a) Initial Pressure



(b) Final Pressure Conventional



(c) Final Pressure Blowdown



(d) Final Pressure Co-Production

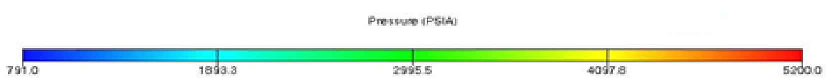
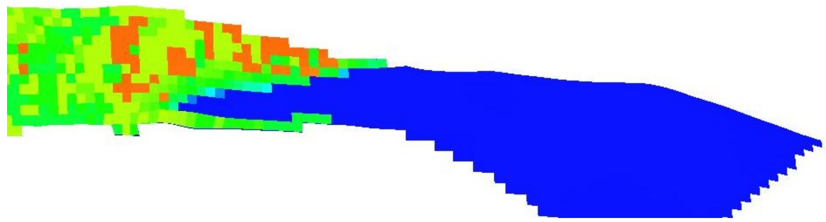
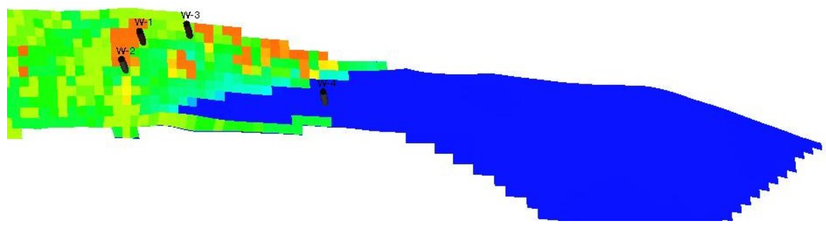


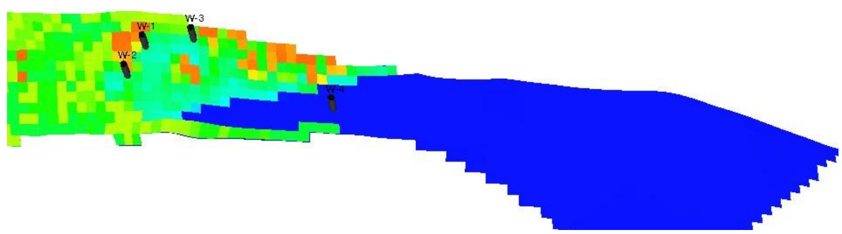
Figure 2: Pressure behavior of production techniques in all four wells.



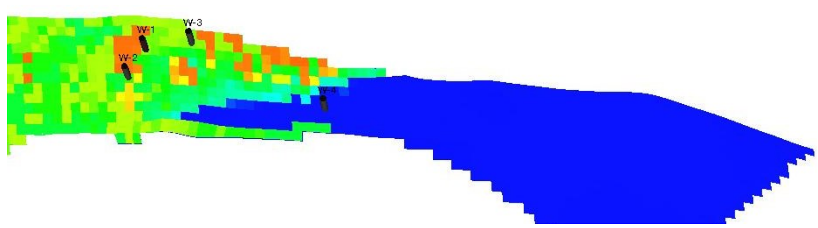
(a) Initial Gas Saturation



(b) Final Gas Saturation Conventional

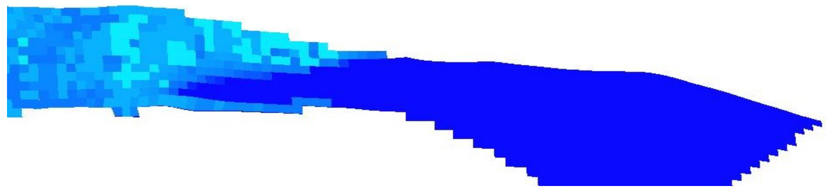


(c) Final Gas Saturation Blowdown

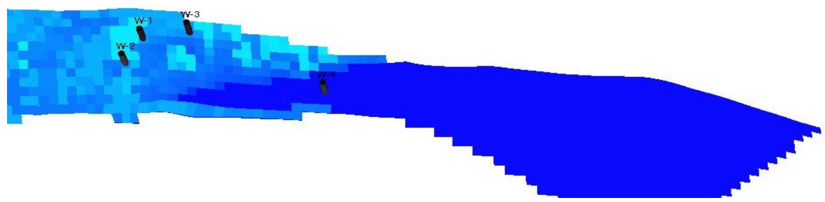


(d) Final Gas Saturation Co-Production

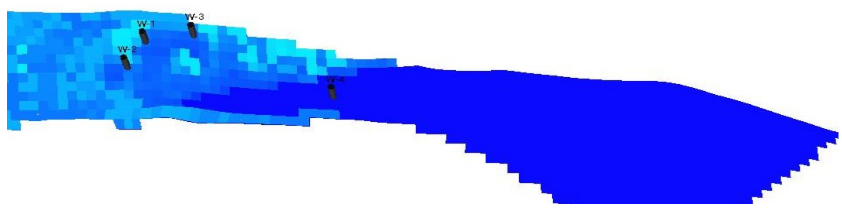
Figure 3: Saturation profile of Production techniques of all four wells.



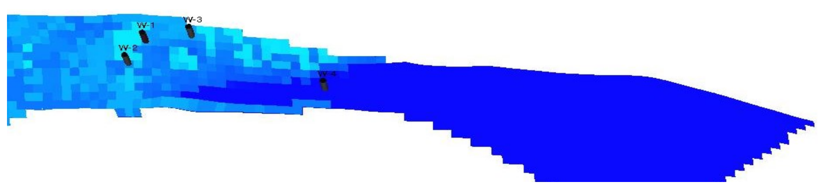
(a) Initial Water Saturation



(b) Final Water Saturation Conventional



(c) Final Water Saturation Blowdown



(d) Final Water Saturation Co-Production

Figure 4: Water saturation profile of all techniques of all four wells.